CLAIMS

What is claimed is:

1. An apparatus for measuring retardance in a sample, comprising:

a sample chamber for receiving the sample;

an illuminator for providing an illumination light;

optics for directing the illumination light toward the sample;

a detector for measuring an intensity of light incident on the detector;

optics for directing light that has interacted with the sample toward the detector;

a first polarizer for selectively transmitting light that is substantially circularly polarized;

a second polarizer for selectively transmitting light that has a selected elliptical polarization state;

a controller for varying a selected elliptical polarization state of the second polarizer to correspond to a plural number of states χ_i with a chosen Poincare latitude and longitude within a distance ε of a chosen pole of a Poincare sphere; and

a processor connected to the detector for determining the sample retardance from the measured incident light intensity obtained when the second polarizer is set to each of the states χ_i;

wherein none of the states χ_i corresponds to circular polarization.

2. The apparatus of claim 1, wherein the illumination light is transmitted by the sample.

3. The apparatus of claim 1, wherein the illumination light is reflected by the sample.

4. The apparatus of claim 1, wherein:

the first polarizer is located between the illuminator and the sample chamber; and

the second polarizer is located between the sample chamber and the detector.

5. The apparatus of claim 1, wherein:

the second polarizer is located between the illuminator and the sample chamber; and

the first polarizer is located between the sample chamber and the detector.

6. The apparatus of claim 1, wherein the number of states χ_i is 2.

7. The apparatus of claim 1, wherein the number of states χ_i is 3.

8. The apparatus of claim 1, wherein the number of states χ_i is 4.

9. The apparatus of claim 1, wherein the second polarizer comprises an electro-optic retarder element.

10. The apparatus of claim 1, wherein the second polarizer comprises at least one fixed retarder and mechanical switching means.

11. The apparatus of claim 1, wherein the illumination light is substantially monochromatic.

12. The apparatus of claim 1, wherein the illuminator comprises a broadband source and a filter.

13. The apparatus of claim 1, wherein ε is 35 degrees or less.

14. The apparatus of claim 1, wherein ε is 20 degrees or less.

15. An apparatus for measuring retardance in a sample, comprising:

a sample chamber for receiving the sample;

a source of illumination light;

optics for directing the illumination light toward the sample;

a detector for measuring an intensity of light incident on the detector;

optics for directing light that has interacted with the sample toward the detector;

a first polarizer for selectively transmitting light that is substantially circularly polarized;

a second polarizer for selectively transmitting light that has one of a selected elliptical polarization state and a circular polarization state;

a controller for varying the polarization state of the second polarizer to correspond to a plural number of states χ_i with a chosen Poincare latitude and longitude within a distance ε of a chosen pole of a Poincare sphere; and

a processor connected to the detector for determining the sample retardance from the measured incident light intensity obtained when the second polarizer is set to each of the states χ_i;

wherein the number of states is five, and wherein one of the states χ_i corresponds to circular polarization.

16. The apparatus of claim 15, wherein ε is 35 degrees or less.

17. The apparatus of claim 15, wherein ε is 20 degrees or less.

18. A method for measuring retardance in a sample in a sample chamber, comprising the steps of:

producing an illumination beam of light;

directing the illumination beam toward the sample;

collecting directed illumination light that has interacted with the sample to form a collected light beam;

directing the collected light beam toward a photodetector;

directing one of the illumination beam and the collected light beam through a circular polarizer;

directing the other of the illumination beam and the collected light beam through a variable polarizer that expresses a plural number of elliptical polarization states χ_i;

measuring an intensity of light incident on the photodetector during each of the plural states χ_i; and

calculating the retardance of the sample using the photodetector light intensity measurements;

wherein the number of states χ_i is four or less and none of the states χ_i is circular.

19. The method of claim 18, wherein each of the plural states χ_i lies within a distance ε from a chosen pole of the Poincare sphere.

20. The method of claim 19, wherein ε is 35 degrees or less.

21. The method of claim 19, wherein ε is 20 degrees or less.

22. The method of claim 18, further comprising the steps of:

measuring the intensity of light incident on the photodetector while the variable polarizer expresses a plurality of states χ_i and the sample is not present in the sample chamber; and

using the measured intensities of light incident on the photodetector when the sample is not present to improve the calculation of sample retardance.

23. The method of claim 22, wherein said measuring the intensity of light with the sample not present in the sample chamber comprises measuring the light intensity with the sample replaced by a calibration target of substantially no retardance and a calibration target of known retardance.

24. A method for measuring retardance in a sample in a sample chamber, comprising the steps of:

producing an illumination beam of light;

directing the illumination beam toward the sample;

collecting directed illumination light that has interacted with the sample to form a collected light beam;

directing the collected light beam toward a photodetector;

directing one of the illumination beam and the collected light beam through a circular polarizer;

directing the other of the illumination beam and the collected light beam through a variable polarizer, wherein the variable polarizer expresses a plural number of polarization states χ_i including a plural number of elliptical polarization states and a circular polarization state;

measuring an intensity of light incident on the photodetector during each of the plural states χ_i; and

calculating the retardance of the sample using the photodetector light intensity measurements,

wherein the number of states χ_i is five and one of the states χ_i is circular.

25. The method of claim 24, wherein each of the plural states χ_i lies within a distance ε from a chosen pole of the Poincare sphere.

26. The method of claim 25, wherein ε is 35 degrees or less.

27. The method of claim 25, wherein ε is 20 degrees or less.

28. The method of claim 24, further comprising the steps of

measuring the intensity of light incident on the photodetector while the variable polarizer expresses a plurality of states χ_i and the sample is not present in the sample chamber; and

using the measured intensities of light incident on the photodetector when the sample is not present to improve the calculation of sample retardance.

29. The method of claim 28, wherein said measuring the intensity of light with the sample not present in the sample chamber comprises measuring the light intensity with the sample replaced by a calibration target of substantially no retardance and a calibration target of known retardance.